MARTIAN TERRAINS

Harold Masursky, M.G. Chapman, P.A. Davis, A.L. Dial, Jr., and M.E. Strobell, U.S. Geological Survey, Flagstaff, AZ 86001

Terrain studies of candidate landing sites for a future rover/sample-return mission to Mars are being conducted to evaluate the geologic and trafficability aspects of each site. An optimum site should have geologic units of widely diverse ages and chemical compositions occurring in close enough proximity and in smooth enough terrain so that a roving vehicle of limited traverse ability (±100 km) could collect representative samples.

In FY 1986, geologic maps were compiled at 1:500,000 and 1:2 million scales of the Mangala Valles, Kasei Valles, Chasma Boreale (north polar) and Planum Australe (south polar) areas, and a study was begun of the topography and surface-roughness characteristics of the Mangala Valles site. Geologic mapping has been greatly facilitated by specially enhanced, high-resolution Viking photographs, such as that shown in Fig. 1, which clarify stratigraphic relations of units that were unrecognized earlier. Photoclinometric profiles of topographic features (Davis and Soderblom, 1984), provide width and depth measurements of four classes of channels, the thickness of some volcanic units, and the throw on some faults. Estimates of the surface roughness of units are being calculated using a newly developed USGS computer program and using measurements derived from Earth-based radar by Tommy Thompson of JPL and Richard Simpson of Stanford.

Studies of the Mangala Valles site are virtually complete. A long, complex geologic history is indicated by stratigraphic relations (Fig. 2) shown on the maps; crater counts of geologic units (Table 1) confirm these relations. Crater-density numbers, when compared with the second model of Neukum and Hiller's (1981) calibration curve, indicate that map units range in age from 4.0 to 0.6 Ga. (The number of craters retained on the youngest unit, Amazonian textured plains material (Table 1), is not sufficient to determine a valid age.) In this area, the ancient cratered terrain of Mars is partly covered by a thick sequence of lobate volcanic units, probably basaltic lava flows, and younger, possibly felsic, volcaniclastic rocks. At least three episodes of small-channel formation have been identified and dated (Table 1). Although many investigators have theorized that most, if not all, Martian channels are ancient (Sharp and Malin, 1975; Carr and Clow, 1981; Pieri, 1980; Baker and Partridge, 1986), our studies show that the small channels appear to range in age as widely as do the large outwash channels (Masursky et al., 1977). However, it is hard to determine whether very narrow channels are volcanic or fluvial in origin. Channels that emerge from the distal end of a lava flow and have leveed banks are probably volcanic in origin; those with tributaries or with alluvial deposits at their mouths are probably fluvial.

Enhanced images, such as that of Fig. 1, show some lava flows pouring over a fault scarp, other flows that stop at the scarp, and one flow that appears to be cut by the scarp. Wide, theater-headed channels dissect some of these flows. Fault movement, lava flows, and channel formation can be dated precisely from these geologic relations.

On photoclinometric profiles of a fault scarp that marks the boundary between the southern highlands and the northern low plains east of Mangala Valles, we measured slopes that range from 8° to 25° and

throw that ranges from 70 m to 2 km.

Ancient degraded channels range in width from 0.7 to 4 km and in depth from 33 to 112 m; the longest channel is 80 km long. Two branches of the main Mangala Valles system are, where measured, 5 and 4.5 km wide and 200 and 300 m deep, respectively; their lengths are 80 and 60 km. North-trending, theater-headed channels are 1 to 3 km wide, 100 to 1500 m deep, and 6 to 60 km long. Young, narrow channels that lie inside and extend beyond the mouths of theater-headed channels are 300 to 800 m wide, 20 to 60 m deep, and 20 to 70 km long.

Profiles of the putative volcaniclastic unit show it to be about 1 km thick where it embays one crater and spills into another.

At the Kasei Valles site, one geologic map at 1:2 million scale and 2 geologic maps at 1:500,000 scale have been completed. The site appears smooth on available low-resolution images and is thus attractive to engineers. However, geologic units are more dispersed than at other sites and long traverses would be needed to collect varied samples.

Geologic maps at 1:2 million and 1:500,000 scales of the Chasma Boreale (north polar) and Planum Australe (south polar) areas show deposits of layered ice overlying deposits of mixed ice and detritus; young dune deposits are also present at the north polar site. A drill mounted on a rover could obtain meter-thick cores of these deposits. Ice phases of the deposits would have to be analyzed <u>in situ</u>; rock inclusions could be analyzed in terrestrial laboratories. These sites also appear to be topographically bland, but they are attractive because layered terrains are easily accessible to direct sampling or drilling.

Geologic maps of the Memnonia and Olympus Rupes sites were prepared earlier and the sites are still being considered. The Memnonia area (mapped by D. Scott <u>in</u> Masursky et al., 1984) displays a wide variety of rock types and compositions, but it lacks channel deposits found at the nearby Mangala site. At the Olympus Rupes site (Morris, 1982), at least three basaltic units were mapped that represent stages in the development of Olympus Mons. When 1:500,000-scale bases for these sites are produced, mapping will be transferred to them.

Studies of the Elysium Mons, Candor Chasma, and Nilosyrtis Mensae sites will be completed in FY 1987. Additional sites that contain channels with stratigraphically dateable ages will be sought and mapped.

We thank our USGS colleagues who have contributed greatly to this study. Image enhancements are being obtained by Bonnie Duck and Jo Ann Bowell, using a program modified by Eric Eliason. Photoclinometric profiles are being generated by P.L. Davis and M. G. Chapman, using a technique developed by Davis and Soderblom (1984). Measurements of terrain roughness are being obtained by combining a formula that obtains surface roughness indicator values with photometric scans (A. Acosta, R. Gurule, personal commun.).

<u>References</u>

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Ga *	System **	Geologic Unit	Cumulative Number of Craters Per 10^6 Km^2			Age Range of Channels
			500 m	1 km	2km	
<0.6	Amazonian	Apt	—	130±90	—	
0.6		Aps	3400±1800	340±90	7±4	
1.0		Apl	4200±1000	440±160	70±50	
1.5		Grooved Mangala Floor	—	700±500	—	
2.5 2.6		AHpi	4000±600	1,200±400 1,230±370	80±35	ch_4 (narrow)
3.2 3.3 3.4	Hesperian	Hpl Hpr Hpi	16,000±2,000 17,000±2,000 17,000±2,500	1,600±400 1,900±300 2,400±300	160±100 260±100 360±140	ch_3 (theater headed) ch_2 (Labou Asopus, Padus)
3.7		NHpi	19,000±2,500	3,000±800	460±300	ch_1 (Degraded)
4.0	Noachian	Nc	40≥40 km diam./10^6 km^2			

* 1 Ga ≅1 B. y., ages derived from model II curve, Neukum and Hiller, 1981

**Divisions taken from Tanaka, in press

Table I. Ages of geologic units and channels, Mangala Valles region, Mars

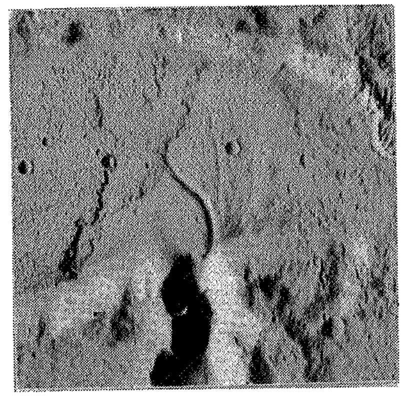

Fig. I Abus Valles; part of VO 455 S II; East Mangala area, Mars

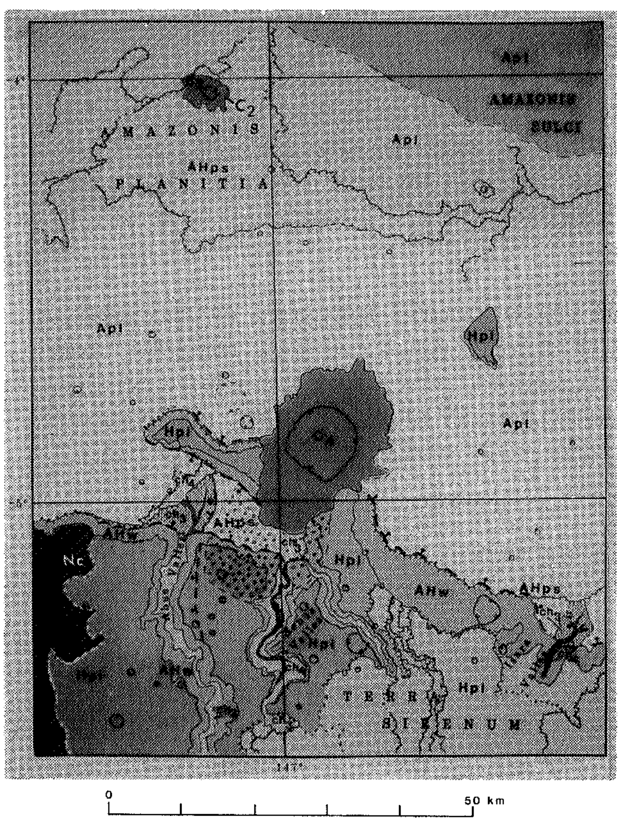

Fig. 2 Geologic map of the East Mangala landing site on Mars

MANGALA EAST
UNITS

- Apt — Amazonian textured plains material
- Apl — Amazonian lobate plains material
- AHps — Amazonian-Hesperian smooth plains material
- AHw — Amazonian-Hesperian wall unit
- Hpl — Hesperian lobate plains material
- Hpi — Hesperian intercrater plains material
- Nc — Noachian heavily cratered plains material

CHANNEL MATERIAL

- ch_4 — Youngest channel floor material
- ch_3 — Young channel floor material and alluvium

CRATER MATERIAL

- C_4 — Young sharp-rimmed crater material with discontinuous secondary crater ejecta
- C_2 — Subdued crater material
- Thin eolian deposits

MAP SYMBOLS

- Contact--Long dashed where approximately located; short dashed where inferred; dotted where buried
- Fault--Approximately located, dotted where concealed. Bar and ball on downthrown side
- Crater rim; dashed where buried
- 13 14 Proposed rover traverse
- Flow front